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Test on the Dynamic Response of the Offshore Wind Turbine Structure with the Large-Scale Bucket Foundation

Puyang Zhang[1,2], Hongyan Ding[1,2], Conghuan Le[3], Xianqing Liu[1]

[1]*School of Civil Engineering, Tianjin University; Tianjin, 300072, China*
[2]*Key Laboratory of Coast Civil Structure Safety (Tianjin University), Ministry of Education, Tianjin, 300072, China*
[3]*State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian, 116023, China*

Abstract

The offshore wind turbines with large-scale bucket foundation is installed in sea area of Qidong city, Jiangsu province of China. Wind tower is high-rise structure, he study on dynamic characteristics of tower structure is very important. The acceleration time interval curve can be obtained under the condition of artificial excitation and natural wind through installing accelerometers , charge amplifiers, data acquisition instrument and so on, on bucket foundation and tower tube. The natural frequency of the tower can be obtained through low-pass filter analysis and Fourier transformation to the acceleration time interval curves. After analysis, the natural frequency of the tower is between 0.3~0.4Hz. Through analysis on the acceleration time interval curve under the wind force function whether under working condition or shut-down condition, import information on the wind-induced response of the structure can be obtained.

*Keywords :*Offshore wind turbine, bucket foundation, dynamic characteristics, natural frequency, test on site.

1.Introduction

The integrated wind turbine structure with large-scale bucket foundation was installed on October of 2010 in Qidong city of Jiangsu province. The foundation can be fabricated onshore and self-floating to the construction site. Wind turbine structure is a high-rise structure, which will be vibrating excited by wind and wave dynamic loadings. In the paper, the testing data of tower and foundation structures are analyzed to obtain the natural frequencies and the wind-induced response of the structure, which can

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provide basic information for the subsequent structural design and checking.

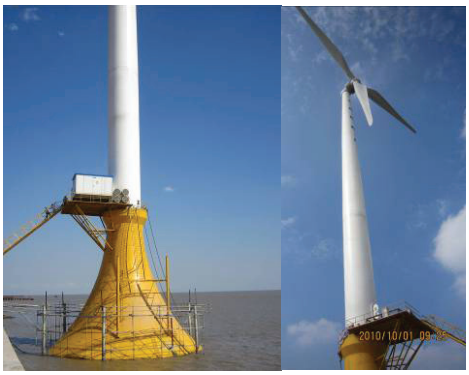

Fig. 1 the structure of wind turbine with the large-scale foundation

2.Layout of Testing points

The parameters fro tower structure are as follows: tower height of 78 m; the outer diameters at the bottom of 4.4m; the external diameters on the top of 2.7m; materials is used of steel; weight of 1290kN. The main measuring instruments are five acceleration sensors, which are set as the top of foundation (point 1), flange between foundation and tower (point 2), the bottom, middle and top of tower (point 3, point 4 and point 5). The X and Y directions are horizontal and the Z direction is vertical for tower.

3.Natural frequency of structure

3.1.The Artificial Excitation Method

The primary process of the method of artificial excitation to obtain the natural frequency is as follows: incentives at a distance of 30m and 90m at the tower from the sea level firstly; data collectives of five measuring points; fast Fourier transform of data to obtain the first-order natural frequency[1]. The related figures are shown below.

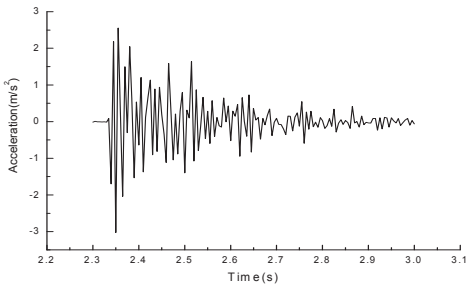

Fig. 2 the decay curve of point 5

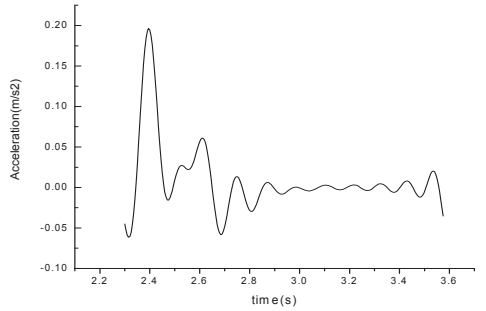

Fig. 3 the low-pass filter curve of point 5

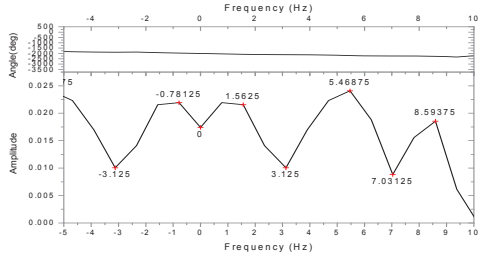

Fig. 4 the amplitude and phase angle curve of point 5

It can be seen from Figure 4, the first natural frequency is 0.78125Hz at point 5. By the same method, the first natural frequencies are 0.78125Hz, 0.75684Hz, 0.75684Hz at point 2,3 and 4, respectively. So, the first natural frequency is between 0.75Hz to 0.79Hz.

3.2.Natural Frequency with Non-Working State

When the fan is in a non-working condition, according to the five-point acceleration time curves, the natural frequencies are also obtained. First, curves of acceleration versus time are low-pass filtered, and then the amplitude and phase angle curve is plot by the Fourier transform. At last, the first order natural frequency is obtained from the amplification effect spectrum of the structure, which is shown as the following figures.

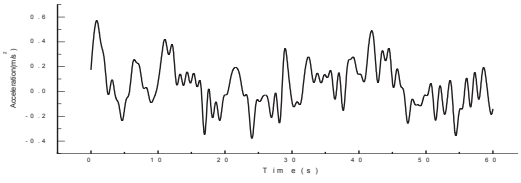

Fig. 5 the low-pass filter curve

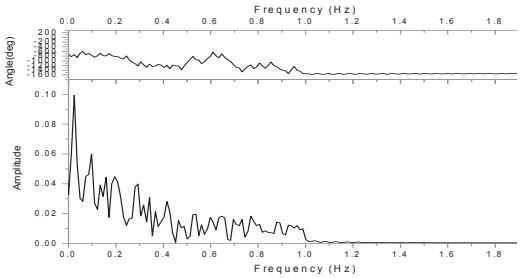

Fig. 6 the amplitude and phase angle curve

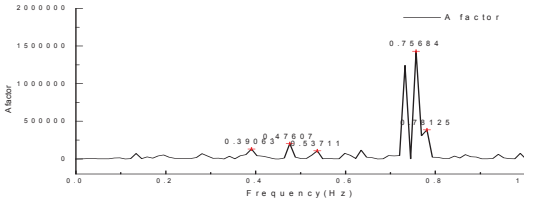

Fig. 7 amplification effect spectrum curve

It can been seen from figure 7, that the first natural frequency is 0.39063Hz.

3.3.Natural Frequency with Working State

Similarly, according to measuring the acceleration curve, the natural frequency is obtained. With the same method for data processing, the corresponding curves are as follows:

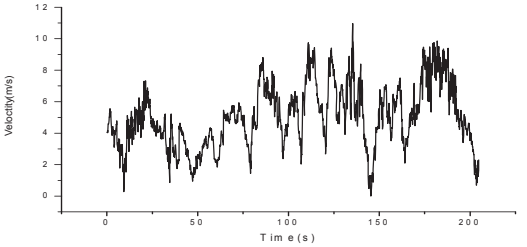

Fig. 8 wind velocity verse time

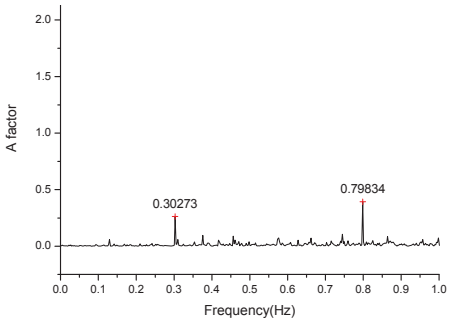

Fig. 9 amplification effect spectrum curve

From the figure 9 of amplification of the spectrum, the structure of the first-order natural frequency is 0.30273Hz.

4.The dynamic properties of wind tower structures by test analysis

4.1.Non-working State

In shutdown state of the fan, the natural wind speed time curves can be applied to the tower structural analysis. In general, a wind speed time curve is simulated by using Davenport spectrum [2]. The corresponding acceleration curves of measuring points are as follows:

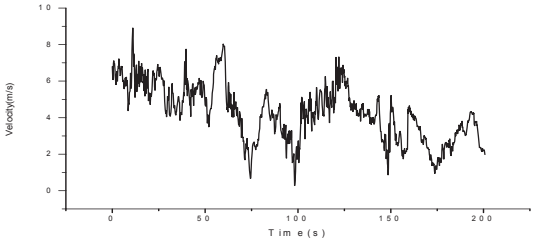

Fig. 10 wind velocity time curve

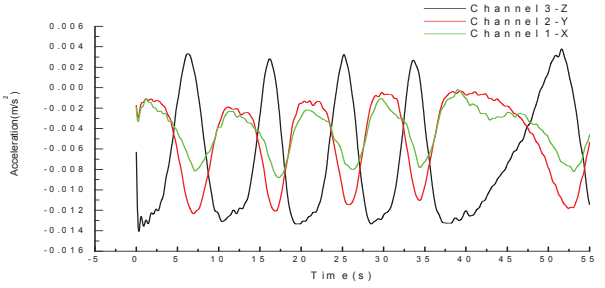

Fig.11 the acceleration time curve of point 1

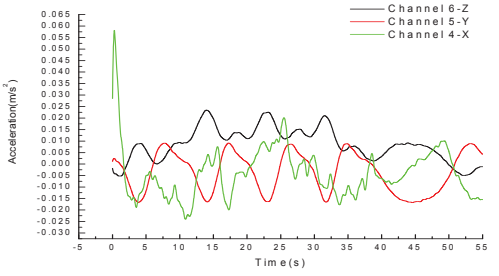

Fig.12 the acceleration time curve of point 2

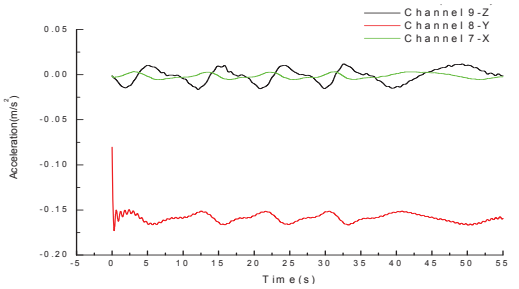

Fig.13 the acceleration time curve of point 3

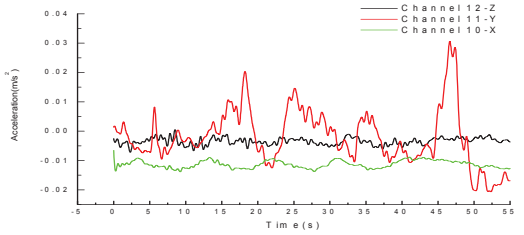

Fig.14 the acceleration time curve of point 4

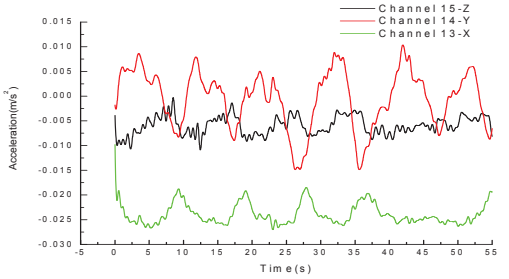

Fig.15 the acceleration time curve of point 5

4.2.Working State

Under working state, the measured wind speed time curves, acceleration curves and the corresponding active power grid are as follows (data monitoring time: December 2010):

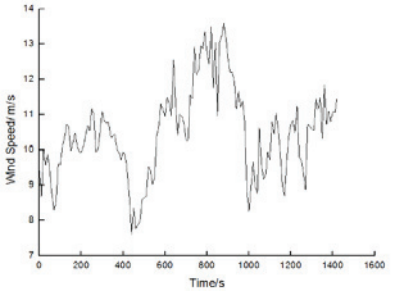

Fig.16 wind time curve

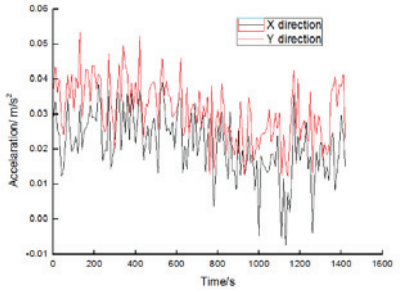

Fig. 17 acceleration time curve

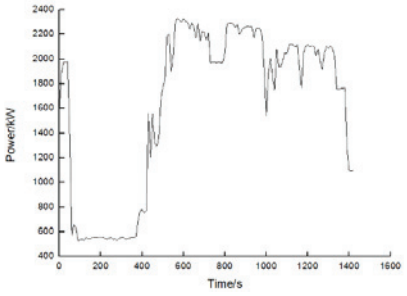

Fig.18 wind power time curve

5.Conclusion

By the acceleration sensor placed on the tower, the acceleration versus time of wind turbine structure can be obtained in artificial and natural wind excitation. The first natural frequency of the structure can be obtained by low-pass filtering and Fourier transform of the measured acceleration versus time. With the analysis method, the structure's first natural frequency is between 0.3Hz to 0.4Hz. From the natural acceleration versus time of structure, the wind-induced vibration accelerations are relatively small, but there will be sudden increasing phenomenon of the acceleration during the working condition, which should be paid more attention in design processing of the foundation.

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